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Cinematic worlds in color – technology, aesthetics, analysis

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Abstract: Keynote Beitrag. Auszug aus der Einleitung: Colors add an immediate and emotionally charged dimension to films. Its significance has often been underestimated in the past. Starting in the mid-1990s an increasing number of scholarly publications have appeared, including Jacques Aumont's seminal book in France (Aumont 1995), Dall'Asta et al. in Italy (1995) and Hertogs / de Klerk in the Netherlands (Hertogs et al. 1996) on color in silent film, followed in English by Dalle Vacche/Price (2006), Wendy Everett (2007), Scott Higgins (2007), Raphaëlle Costa de Beauregard (2009), Richard Misek (2010), Paul Coates (2011), and several important publications by Sarah Street (Street 2009, Brown et al. 2012, Brown et al. 2013) and Joshua Yumibe (2012 and Street / Yumibe 2019), in German Susanne Marschall (2005) and Christine N. Brinckmann (2014, in English 2015), and in journals including issues of Film History (2000 and 2009) and of 1895 (2014). [...]

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Film Techniques and Technology: Illusion, Reality, Virtuality, Innovation

영화기술: 환상, 사실, 가상, 혁신

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기조연설

Keynote Speech

영화적 세계와 색채의 문제: 테크놀로지, 미학, 분석

Cinematic Worlds in Color. Technology, Aesthetics, Analysis

바바라 플뤼키거 Barbara Flueckiger

스위스 취리히대학교 영화학 교수. 스위스 국내 및 국제 영화 제작 현장에서 일하며 영화와 관련을 맺었다. 이후 대학에서 영화이론과 영화사를 공부했다. 현재 기술과 미학의 상호관계를 주제로 연구를 수행하고 있다. 2015년 영화 색채 기술과 미학에 관한 연구 프로젝트의 탁월성을 인정 받아 유럽연구위원회(ERC)가 수여하는 연구기금 Advanced Grant를 수혜했다.

웹사이트: http://zauberklang.ch/filmcolors

Professor for film studies at the University of Zurich. Before her studies in film theory and history, she worked internationally as a film professional. Her research focuses on the interaction between technology and aesthetics. In 2015 she was awarded the prestigious Advanced Grant by the European Research Council for a research project on the technology and aesthetics of film colors. Website: http://zauberklang.ch/filmcolors

Cinematic Worlds in Color. Technology, Aesthetics, Analysis

Barbara Flueckiger

University of Zurich

Introduction

Colors add an immediate and emotionally charged dimension to films. Its significance has often been underestimated in the past. Starting in the mid-1990s an increasing number of scholarly publications have appeared, including Jacques Aumont's seminal book in France (Aumont 1995), Dall'Asta et al. in Italy (1995) and Hertogs / de Klerk in the Netherlands (Hertogs et al. 1996) on color in silent film, followed in English by Dalle Vacche/Price (2006), Wendy Everett (2007), Scott Higgins (2007), Raphaëlle Costa de Beauregard (2009), Richard Misek (2010), Paul Coates (2011), and several important publications by Sarah Street (Street 2009, Brown et al. 2012, Brown et al. 2013) and Joshua Yumibe (2012 and Street / Yumibe 2019), in German Susanne Marschall (2005) and Christine N. Brinckmann (2014, in English 2015), and in journals including issues of *Film History* (2000 and 2009) and of *1895* (2014).

However, these investigations rarely considered an interdisciplinary approach that combines deep investigations of film color technology and material analysis with systematic investigations into color film aesthetics and narrative patterns including the cultural context on a large scale.

In this paper such an interdisciplinary approach will be presented based on several research projects that have been established and executed in the last few years by the author and her research teams.

The most important foundation of this research is the *Timeline of Historical Film Colors* http://zauberklang.ch/filmcolors/, a comprehensive interactive web resource on the history, technology, aesthetics, restoration and scientific analysis of film colors. The *Timeline* contains hundreds of primary and secondary papers, selected analyses, patents, reports of film restorations, colorimetric measurements and – most importantly – over 20.000 photographs of historical film prints and negatives, captured in film archives, in Europe, the United States and Japan.

Technology

The *technobole approach*, based on an essay by Frank Beau (2001) and elaborated by the present author in various research projects, combines a humanities approach to film aesthetics with a deep investigation into the technical foundations. It takes epistemological factors and cultural contexts for the formation of technologies into account and considers the fact that technology emerges in a network of scientific insights and broader trends in a given period and society. Currently the cultural perspective is being extended further by Noemi Daugaard and Josephine Diecke (Daugaard / Diecke 2019) with reference to the social construction of technology (SCOT) (Bijker et al. 1987) that proposes a network of interactions between societal needs and technical innovation. In addition, their research takes discourse analysis and hegemonic structures in the distribution of power into account.

Since the invention of cinema there has been a quest for technical solutions to introduce color into film. During the first three decades of cinema, applied colors such as tinting, toning, hand and stencil coloring were the norm. In these technical approaches color was added to each black and white print individually. While these colors survived on the historical nitrate film prints in archives, later prints of these films were produced on safety film stock in black and white when nitrate films were prohibited due to their combustibility. As a result, later generations of viewers lost the memory of films' colored past and perceived these early films in black and white.

From the perspective of a theory of representation, applied colors produce autonomous colors with no direct link to the worlds they depict. As in paintings, the colors follow the artistic liberty of choices taken by the colorists, by directors or production companies, choices that are usually not documented nor attributed to individuals in the sense of artistic intentions. Tinting and toning color temporal segments in monochrome or—in the case of their combination—into bi-chrome color schemes through immersion into chemical baths. For tinting, these baths contained organic dyes that colored the emulsion of the film uniformly. Such tinting can be identified by the colored brighter parts of the film image and most importantly by the coloring of the perforation area. Toning by contrast is the complementary process by which the silver in the emulsion is replaced by colored pigments or dyes, thereby keeping the white parts uncolored while the darker parts contain increasing amounts of colors.

Figure 1 Tinting in < MALOMBRA, 1917> *(Carmine Gallone) (left)*
toning in <VOYAGE AUTOUR D'UNE ÉTOILE A VOYAGE AROUND A STAR, 1906> *(Gaston Velle) (right)*
Credit: Cineteca di Bologna.

In hand and stencil coloring the dyes are applied to individual areas in the image composition, either by tiny brushes or velvet bands. Stencils were cut out from a positive, often with the help of a pantograph to improve details in the small film frames. Color application results in sharper borders of the colored parts. There are pronounced differences between and within each of these early film color technologies, both with regard to their aesthetic appearance and their functions in the creation of cinematic worlds.

While early applied colors have received increasing attention (Yumibe 2012, Rakin 2018, Fossati et al. 2018), it is less well known that so-called mimetic color processes evolved in parallel from the early days of film production on. In contrast to applied colors, mimetic colors aim at reproducing the colors of the world in front of the camera by a mechanical or chemical process, or by a combination of both, to create an equivalence between the appearance of color in the world and its depiction on film.

Figure 2 Handcoloring in BEGINNING OF THE SERPENTINE *(left), stencil color in* LA FÉE AUX FLEURS *(FRA 1905, Gaston Velle) (right). Credit: Library of Congress.*

Most of these technical approaches to create mimetic film colors are based on inventions in the field of still photography and split the color spectrum into two or three spectral bands. However it turned out that the high frame rate of film with 16 to 25 frames per second made the translation from still photography to film a much greater challenge than initially assumed by inventors. Not only did real-time frame rates require short exposure times, which conflicted with the slow film stock, but they also required complex solutions in recording and/or projection, which went against the film industry's quest for standardization and simplicity. In the long run it turned out that cinema owners were the most conservative group, strictly opposing complex projection systems that were confined to the screening of one single color process.

A classification for mimetic film color processes as proposed on the *Timeline of Historical Film Colors*, based on previous work by E.J. Wall (1925), Adrian Cornwell-Clyne (1951), Roderick T. Ryan (1977), Gert Koshofer (1988) and others, makes a fundamental distinction between additive and subtractive processes. Additive colors are admixtures of colored light, either by simultaneous or sequential projection. Subtractive colors, on the other hand, filter the colors through layers of dyed emulsion.

It is evident that this short paper cannot do justice to the many processes and solutions invented during the course of film history. Therefore the paper will focus on some significant inventions that were formative for the field.

Kinemacolor, introduced in 1908, was among the first mimetic color systems to become commercially successful (Hanssen 2006, Jackson 2011, McKernan 2013). It was an additive two-color process that captured two records per image through rotating red and green filters on black-and-white film. Thus the two records per frame were captured successively, an arrangement called temporal parallax. In projection—again through rotating red and green filters—the slight temporal deviation between the two images caused color fringes.

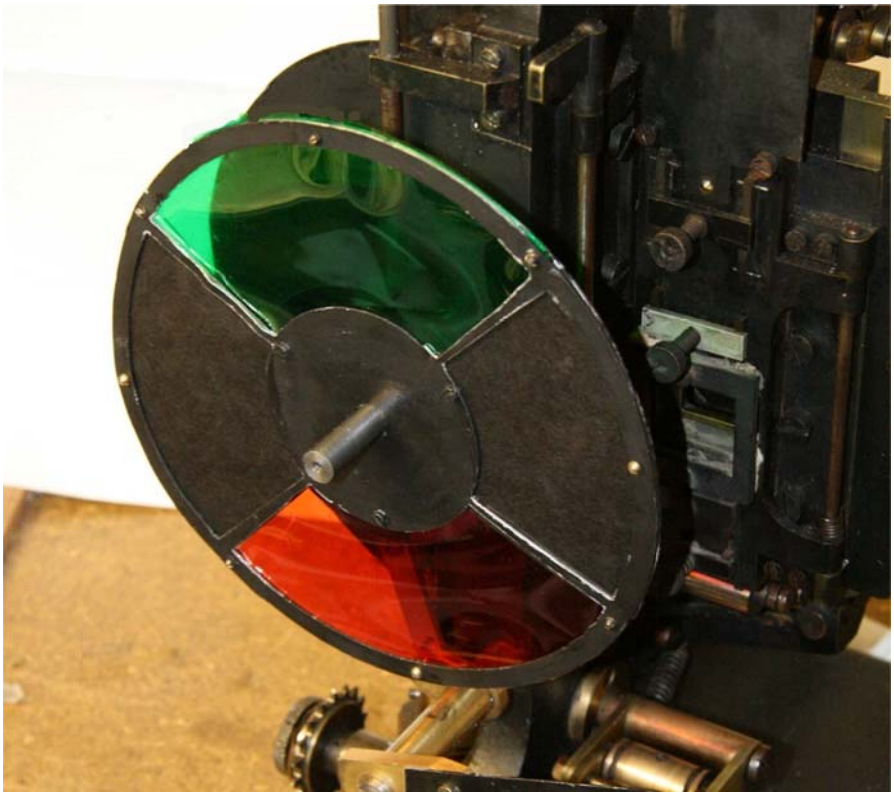

Figure 3 Red and green rotary filters in Kinemacolor. Credit: Brian Pritchard.

A second path in additive color systems was based on the principle that the human eye is able to create a color impression by merging colored dots adjacent to each other if they are small enough. Pointillist paintings in the late 19th century made use of this psycho-physical insight. Photographic color processes soon followed, most notably the Autochrome process by the Lumière brothers who used colored potato starch grains in red, green and blue to create a small-scale colored mosaic structure on photographic glass plates (Lavédrine / Gandolfo 2009). Similarly Dufaycolor consisted of red, green and blue lines, crossing each other and arranged diagonally on the film's base through which the black and white emulsion was exposed. It was one of the more successful color processes of the 1930s, used for instance for documentaries (Brown 2002), for amateur films, and also for Len Lye's abstract animations.

Figure 4 Photomicrograph of Dufaycolor (left). Credit: Silvana Konermann. Dufaycolor sample (right). Credit: National Science and Media Museum Bradford.

Subtractive processes finally won the quest for viable and sustainable color processes. Technicolor struggled for almost two decades to invent a successful three-color process (Layton / Pierce 2015, Flueckiger 2018). After a brief period of success with the Technicolor No. III two-color process in the late 1920s and early 1930s, the company understood the rules of the game and dominated color film production with the three-strip process Technicolor No. IV for almost two decades between 1935 and 1953. The company offered a workflow that was strictly controlled by Technicolor including the company's Color Advisory Service that oversaw the creation of the films' color schemes.

Three black-and-white film negatives were run through the special and bulky Technicolor camera simultaneously and exposed through a beam splitter. From the three black and white separations matrices were created by hardening the silver containing parts through a tanning process while the soft parts of the emulsion were eliminated to form wash-off reliefs for the dye-transfer printing in the subtractive primaries yellow, cyan, and magenta (Ball 1935).

Figure 5 Yellow, magenta and cyan are printed in the dye-transfer process to form the color image in Technicolor No. IV. Credit: Gert Koshofer Collection.

This essentially mechanical process was eliminated by chromogenic film stocks that began to emerge in the late 1930s, for professional film production first with the positive-negative process Agfacolor, later followed by Eastmancolor, Fuji Color and many derivatives of Agfacolor.

In chromogenic film stocks the three subtractive dyes are embedded in several emulsion layers in the form of couplers that are then developed in the lab to form the image through color clouds while the silver is eliminated by bleaching (Heckman 2013, Ryan 1977). Chromogenic films' success in overcoming the dominance of Technicolor was due largely to the elimination of the demanding shooting controlled by Technicolor that required not only the heavy Technicolor camera, but also special operators provided by the company. By contrast chromogenic film stocks were shot in normal cameras. The complexity was shifted away from the site of film production into highly specialized companies for the chemically demanding production of film stocks, while development of the camera negatives and printing of the positives were transferred from the monopoly of one company to many competing film labs.

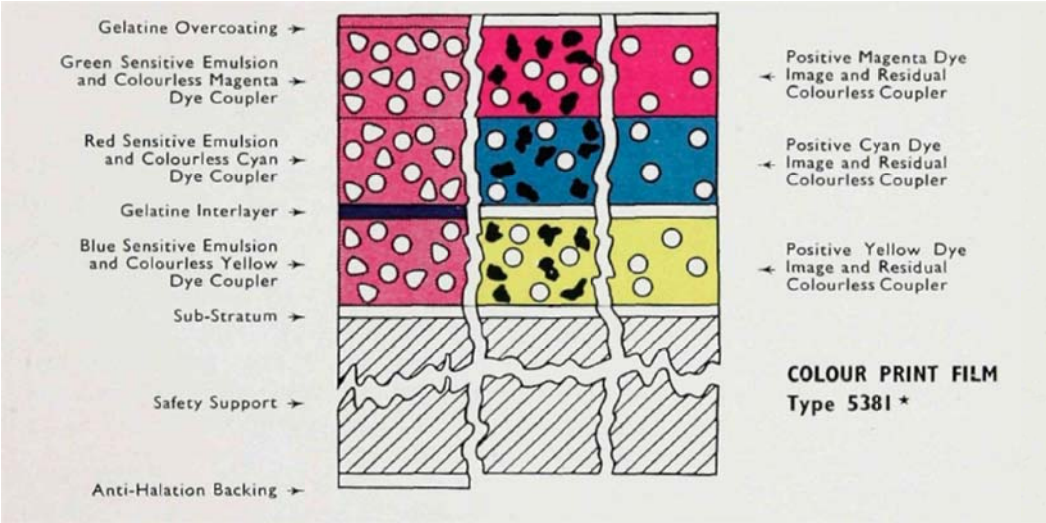

Figure 6 Layers in chromogenic film stock.

Aesthetics

Material Aesthetics and the Concept of Faktura

Depending on the technical foundation and influenced by culturally defined notions of color harmonies and color conventions, aesthetic patterns of film colors evolved over time.

Several aspects need to be addressed in the complex topic of film color aesthetics, but the most important concept for the investigation is related to the interaction of the material foundation of a color film stock with choices made for the selection of specific hues and materials in cinematography, production and costume design. The term *material aesthetics* focuses on this interaction between film stocks' material properties and the color aesthetics in a given group of films produced on this film stock. This concept proposes a feedback loop between the technical and material possibilities and limitations with the mise-en-scène including image composition, lighting, and the material properties of costumes, objects and locations.

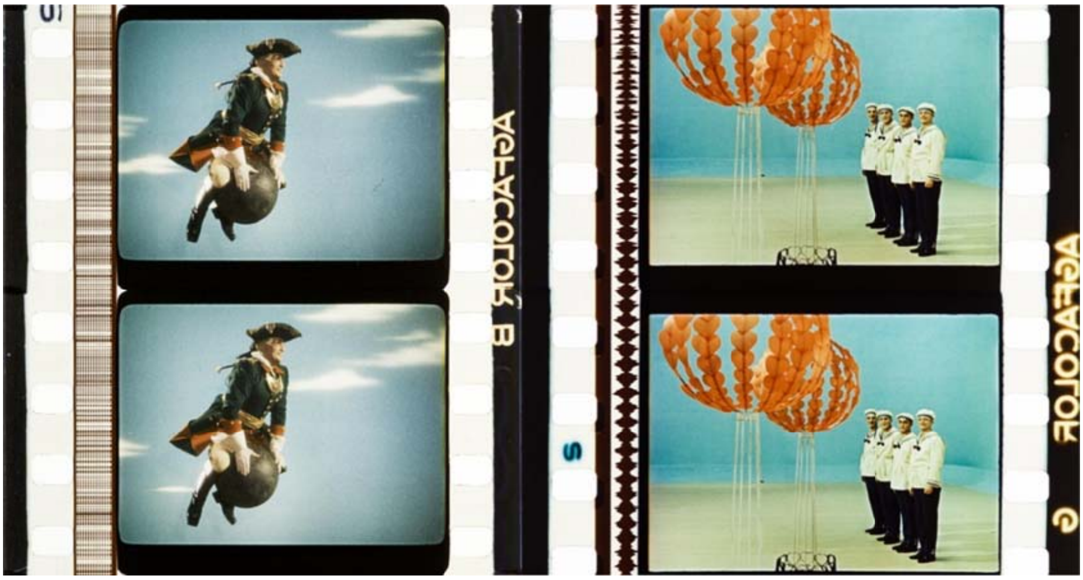

Figure 7 One of the earliest Agfacolor films <Münchhausen The Adventures of Baron Munchausen, 1943> *(Josef von Báky), copyright Murnau Foundation (left)*
and the later Agfacolor film <Lea aus dem Süden, 1963> *(Gottfried Kolditz), copyright DEFA Foundation.*

Therefore, the greatest care has to be given to the color reference for the investigation. While for practical reasons it is necessary to resort to digitized films on DVD or Blu-ray, it is mandatory to investigate and document historical film prints as a reference to understand the material aesthetics of various color processes and corresponding historical film stocks.

Material aesthetics is extended by the concept of *faktura*, established in Russian formalism in the 1920s. Faktura denotes the interaction between a carrier and the application of colors in layers, including binders and film emulsions. More specifically, it describes the three-dimensional arrangement of the different layers present in a film stock as well as the images' texture created by film grains, dye clouds, patches of colors or brush strokes. Many aesthetic features such as translucency, image resolution, rendition of details, contrast rendition are directly linked to a material's faktura.

Figure 8 Faktura in various hand and stencil colored films.

The concept has gained increasing significance in light of current digitization practices. Not only do they often disregard the characteristics of faktura, but by the inherent process of scanning they reduce the three-dimensional structure of a film to a two-dimensional rendition of a film's image. As mentioned on several occasions (see, e.g., Flueckiger 2012), this reduction must be discussed with the dichotomy between *imago* (image) and *struttura* (structure) proposed by Cesare Brandi in his *Theory of Restoration* (Brandi 1963), because every digitization is a single reading of a film element under certain conditions and thus severs the image from its material foundation, threatening a cinematic work's integrity (Flueckiger et al. 2020 [forthcoming]).

Color Schemes and Color Contrasts

Color perception is relational in many ways. It depends on the highly complex interaction of colors—often referred to as color harmonies or color contrasts—and also relates to culturally defined norms and preferences at a given period. In opposition to hermeneutic interpretation, the aesthetics of colors focuses on their sensory appeal as an artistic means of expression, and not on some questionable meaning loosely and arbitrarily defined by culturally established conventions such as red for love or aggression, green for envy or hope, white for innocence, etc. (see Eco 1985 for a critical discussion of color meanings).

Figure 9 Three-dimensional structure (struttura) (top) vs. two-dimensional image capture (imago) (bottom), cemented Technicolor No. II with typical reflection properties.

By *color scheme* we understand the organization of specific colors within a frame or film sequence. It includes the relationship between colors related to the three dimensions of hue, saturation and lightness. Hue is defined by a color's angle in a color wheel, for instance red, blue, green or yellow. Saturation is related to a color's chroma and purity. Lightness denotes the perceived brightness of a color. Depending on the color system these dimensions either form a cone, as in the HSV model, or more complex non-linear spaces, as in perceptually uniform systems such as the Munsell Color Tree (Munsell 1919) or the CIE L*a*b* (CIE LAB) system introduced by the Commission internationale de l'éclairage CIE in 1976.

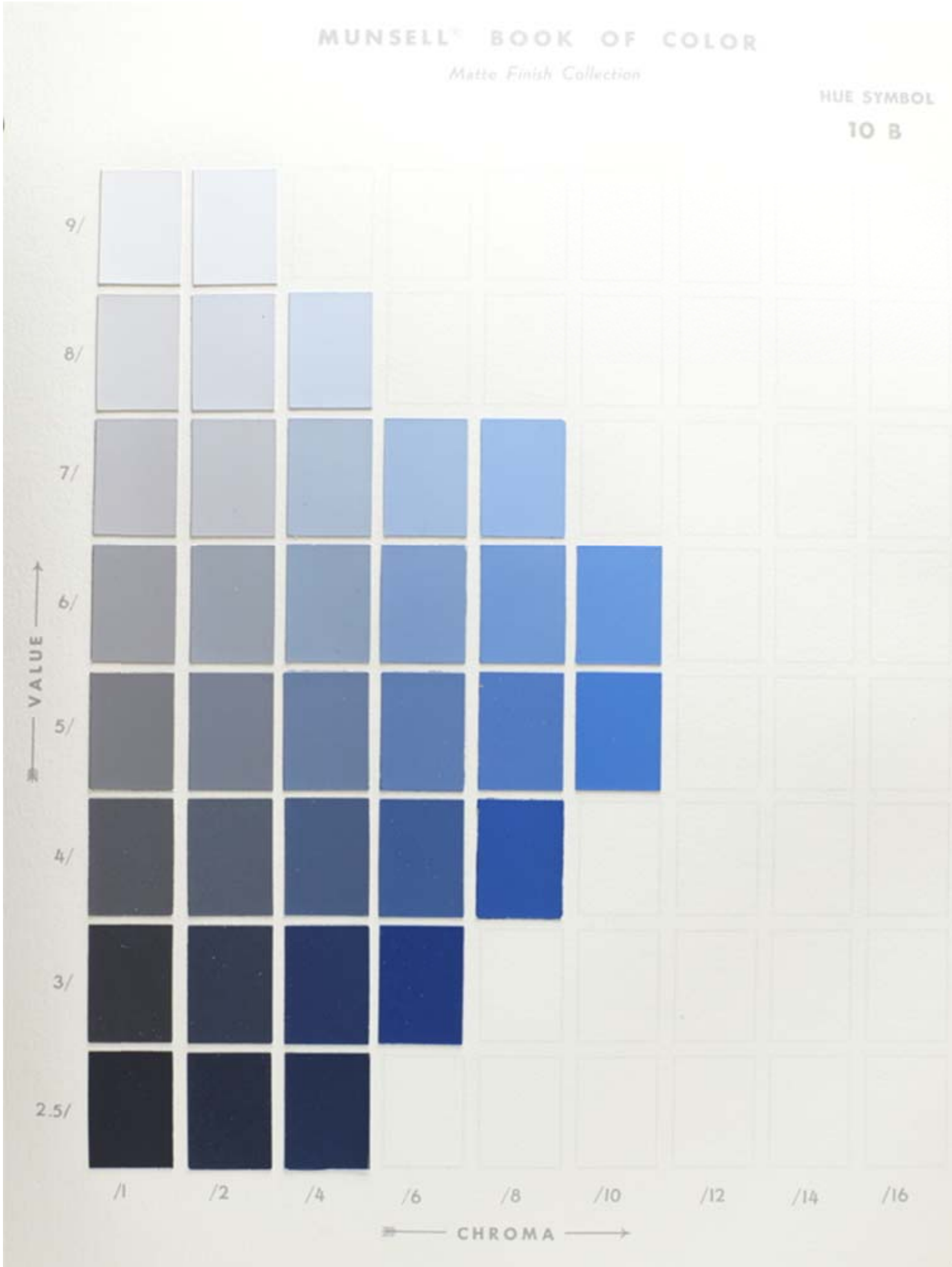

Figure 10 Munsell color system with the dimensions value (lightness) and chroma.

A typology of color schemes describes them in a consistent way by considering the relationships between colors, the properties and the numbers of colors present in an image or sequence.

- *Monochrome* color schemes consist of only one hue in different shades along the saturation scale. They are dominant in tinted or toned films and increasingly again in certain genres from the 1980s onward when colored illumination or colored filters were applied, as is often the case in the works of cinematographer Sławomir Idziak, and then again in digital cinematography as for instance in <*Blade Runner 2049*, 2017>.

Figure 11 Monochrome color scheme in <Blade Runner 2049, 2017> *(Denis Villeneuve)*

- *Restrictive* color schemes make use of only a small number of hues, most of which are also rather unsaturated earth tones. For decades, restrictive color schemes were touted for 'tasteful' use of colors in film, famously by Technicolor's leading color consultant Natalie Kalmus (Kalmus 1935).

Figure 12 Restrictive color scheme in <The Life and Death of Colonel Blimp, 1943> *(Michael Powell; Emeric Pressburger). Credit: British Film Institute BFI.*

- *Gaudy* or *hyperchrome* color schemes combine a higher number of colors, usually more than three distinct, often saturated colors. Hyperchrome color schemes differ from merely gaudy ones by clashing contrasts of saturated hues. Rarely do gaudy or hyperchrome color schemes extend over a full film; most often they are constrained to either specific milieus, fantastic worlds, or narrative climaxes and musical numbers.

Figure 13 Hyperchrome color scheme in <GENTLEMEN PREFER BLONDES, 1953> *(Howard Hawks). Credit: Library of Congress.*

Color contrasts are closely related to color schemes. They describe relationships of colors with regard to a corresponding color system, often with a normative ideal of 'good', 'tasteful' or 'harmonious' color combinations. Normative assumptions about color harmonies date back to Aristotle with a spiritual dimension that persisted from Johann Wolfgang von Goethe's *Farbenlehre* (Goethe 1808) to Bauhaus artist and theoretician Johannes Itten's typology of color contrasts (Itten 1970).

Figure 14 Johannes Itten's Farbstern (color star).

Based on his *Farbstern* (color star), Itten proposed eight different types of color contrasts, seven of which are related to spatial arrangements in image compositions, while successive contrasts take the temporal development of colors into account. Not all of these contrasts have the same significance for film aesthetics. Therefore the following list concentrates only on the most pervasive types:

- *Cold-warm contrast* combines colors that are associated with notions of temperature, usually blue to blue-green vs. red to orange, but also cool pink combined with warm red.

Figure 15 Cold-warm contrast in <WEST SIDE STORY, 1961> *(Jerome Robbins; Robert Wise). Credit: Academy Film Archive.*

- *Complementary contrasts* are defined as hues located at an angle of 180° in the color star or the HSV model. The complementary contrast has always been the strongest of all contrasts, based on physiological foundations where inhibitory processes following adaptation create an after-image in the complementary hue. For example, if you focus on a red dot for a certain time, a green dot appears when the red dot is taken away. Entire films are based on mainly red-green combinations, such as <*LE FABULEUX DESTIN D'AMELIE DE MONTMARTRE AMELIE*, 2001> or, more daringly, <*DICK TRACY*, 1990>.

- *Saturation contrast* is defined by colors in varying degrees of saturation that direct the spectators' eyes to the saturated image areas. Often the most saturated colors are attributed to the female protagonist and direct attention to her appearance.

Itten established his typology with a normative intention to identify and suggest 'good' choices in color design. Such normative reasoning survived for decades in filmmaking and criticism for and against certain uses in color films.

Figure 16 Red and green complementary contrast in <THE ADVENTURES OF ROBIN HOOD, 1938> *(Michael Curtiz; William Keighley), saturation contrast in* <MOULIN ROUGE, 1952> *(John Huston). Credit: UCLA Film & Television Archive.*

Textures, Patterns, and Surfaces

Color appearance is not confined to the dimensions of hue, saturation, and lightness. Surface properties and small-scale variations matter as much as choices of certain colors or color combinations. As outlined in the section on material aesthetics above, there is a feedback loop between material properties of film stocks produced in certain technical color processes and material properties of the world in front of the camera.

The use of patterns—variations of surface colors—not only follows trends in fashion, art and design but also relates closely to film stocks' spatial resolution and ability to render such details in a convincing manner. As outlined in an earlier publication (Flueckiger 2018), Technicolor's dye-transfer process had difficulties in reproducing small-scale color variations due to the process' highly vulnerable registration of the three color separations in printing. Such problems were absent when three color layers were present in the film stock and exposed simultaneously as in chromogenic stocks. As film restorer Anke Mebold noticed, in early Agfacolor films there is invariably a female character wearing a dress with a tiny pattern in the primary colors of red, green, and blue. Tweed with its small structure in adjacent, mostly desaturated colors is ubiquitous in men's costumes used in Technicolor films.

But an abundance of patterns and material details is also present in some monochrome color schemes of tinted and toned films. This trend is certainly related to the period's preference for ornaments (Echle 2018) in Art Déco and Jugendstil. In Cecil B. DeMille's early tinted and toned films, often combined with artful intertitles in the demanding Handschiegl process, the excessive use of highly varied material combinations of shimmery, shiny, sparkling materials with fur and feathers enriched the ornate image compositions. Similarly, in the 1920s stencil colored films tended increasingly to the display of color variations in costume and interior design, most notably in fashion films, though also in documentaries and feature films.

Figure 17 An abundance of surface variations and patterns in the tinted film <THE WOMAN GOD FORGOT, 1917> *(Cecil B. DeMille) (left). Credit: George Eastman Museum, and subtle details in a stencil colored fashion film (right). Credit: National Science and Media Museum Bradford.*

Textures differ from patterns by their three-dimensional structure. They are often associated with desaturated earth tones in cozy, rural environments, wooden cabins, brick and stone walls, or as contrast to uneasy encounters with rough surfaces in rocky landscapes or on rubble and pebbles. Invariably textures address haptic perception.

Analysis

There are several ways in which the research team performs aesthetic and material analysis of film colors.

At the core of the methods applied in the ERC Advanced Grant *Film Colors* there is a *computer-assisted workflow* that combines manual video annotation and analysis performed with a controlled vocabulary and a set of relational databases with deep learning tools (Flueckiger et al. 2017, Flueckiger 2017, Flueckiger / Halter 2018, Halter et al. 2019 [in press]).

It is based on neo-formalist film analysis and historical poetics as introduced by Kristin Thompson (1988) and David Bordwell (1989). The analysis aims at identifying shifting aesthetic patterns in a large corpus of 400 films produced between 1895 and 1995 to gain a deep understanding of the relationship between film color technology and aesthetics. The method will be presented in more detail in the next paragraph.

A second approach targets the *material analysis and documentation* of historical color film stocks. This type of investigation is executed by Giorgio Trumpy and combines spectrophotometry with multi-spectral imaging, colorimetry and image processing (Trumpy / Flueckiger 2018 and 2019). On the one hand, such measurements aim at the identification of historical film prints. Therefore, the results of these measurements are included in the *Timeline of Historical Film Colors* to enable film archivists and restorers to do their assessments based on this information. On the other hand, such material analysis is an important part in understanding material-aesthetic properties based on scientific insights about material composition and physical properties. Finally, these investigations provide important basic research for the digitization and restoration of analog film materials, most importantly faded chromogenic stocks.

Video Annotation and Computer-assisted Analysis

Digital methods in humanities, in short *digital humanities*, are increasingly applied for the investigation of art works, although linguistic analysis remains the main application area of digital tools for research in the humanities. In general, digital humanities approaches remain sparse in the field of audio-visual analysis and even more so when aesthetic investigations come into play (see Stutz 2017, Heftberger 2018, Olesen 2016 for overviews). Not only are these complex areas of investigation that need human intervention to produce meaningful results, but moving images are also much more data-intensive than text or still images.

Several video annotation tools were established in the past (see Gruber et al. 2009, Giunti 2014, Flueckiger 2017, Melgar et al. 2018). However, many of them were abandoned after the end of research projects, creating a slump in 2015 when ERC Advanced Grant *FilmColors* started. The team set out with an existing video annotation tool, ELAN (https://tla.mpi.nl/tools/tla-tools/elan/), for the temporal segmentation of the films to be analyzed. Soon it became obvious that this software, although highly sophisticated, did not cover essential needs of audio-visual analyses because it was initially created for speech analysis. Therefore, in collaboration with the University of Zurich's Visualization and MultiMedia Lab (VMML) of Renato Pajarola, team member Gaudenz Halter developed the visual annotation and analysis tool VIAN (Flueckiger / Halter 2018, Halter et al. 2019 [in press]).

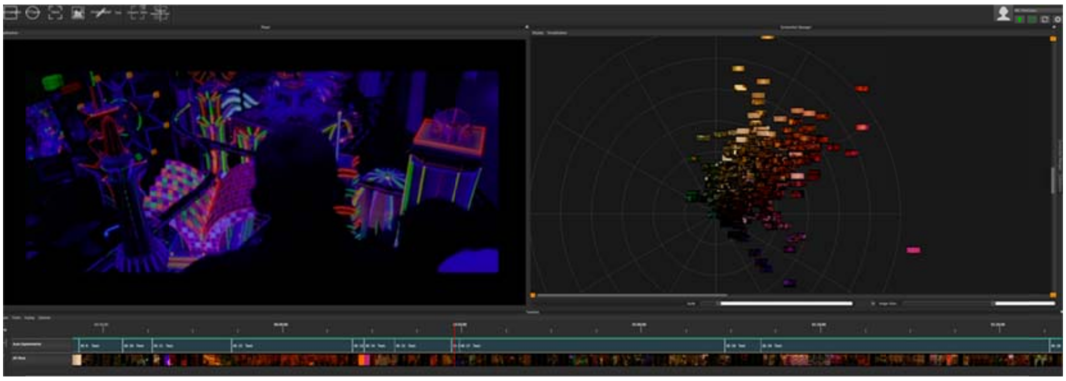

Figure 18 Screenshot of the video annotation and colorimetry in VIAN, developed by Gaudenz Halter.

In the established workflow, first the films were temporally segmented in the video annotation tool according to the consistency of color schemes. The resulting data were then imported into an analysis database and manually annotated by a controlled vocabulary that consisted of 1,200 items including the description of hues. All the concepts were defined and illustrated in a glossary database. Filmographic information was listed in a corpus database. As mentioned earlier, all these databases were connected with each other in a relational database architecture. A massive amount of data resulted from these analyses of a corpus of 414 films, with 17,000 segments, 170,000 screenshots and more than 500,000 summations. These database structures and results are now implemented in VIAN for the evaluation and visualization of the data.

Figure–Ground Separation with Deep Learning Tools

Relationships between characters and their environment are one of the most significant and persistent topics for the analysis of film color aesthetics, predated by considerations of these relationships in art history at the fin-de-siècle and in the early 20th century, for instance in the works of Adolf Hildebrand or Alois Riegl (Schweinitz 2016). Color attribution, color relationships as discussed in section *Color Schemes and Color Contrasts*, image composition and lighting form the basis of corresponding aesthetic features to create spatial impressions in two-dimensional representations in images and films. Movement is an additional time-and-space-related parameter that moderates figure–ground relationships and their choreography in mise-en-scène.

Therefore, one of the fundamental features of VIAN is the automatic extraction of characters from the background. Early in 2017, the research team set out to establish deep learning tools for this task (Flueckiger et al. 2017), based on the object recognition software YOLO (Redmon et al. 2015). YOLO creates *bounding boxes* around the identified characters and objects and labels them verbally. In the pipeline programmed by Noyan Evirgen it was connected to a depth estimation algorithm (Ha 2016) to extract the characters aided by GrabCut (Rother et al. 2004).

Confronted with the large dataset of the results, this pipeline proved to be too slow. Therefore Gaudenz Halter resorted to semantic segmentation (Zhao et al. 2016) that also provides subsegmentation of characters to analyze costumes, hair and skin tones. Skin tones are of particular interest in the analysis of films, because film color technologies have always been calibrated in such a way as to render, in particular, the Caucasian complexion of female protagonists in a convincing way (Dyer 1997).

Visualization

In addition to the database analysis a large range of visualization methods were developed to produce insights in non-verbal diagrammatic representations. In the past, different visualization methods for films and artworks were established, see for instance the approaches by Lev Manovich (2012 and 2015), Everardo Reyes-García (2014, 2017), Lindsay M. King and Peter S. Leonard (2017). Frederic Brodbeck (2011) extracted color palettes with K-means and plotted them in circles with his software Cinemetrics. Kevin Ferguson (2013 and 2016) created beautiful renditions of films in summary visualizations. Several film scholars applied existing approaches such as ImageJ (Ross 2007) and ImagePlot (Manovich 2013) for the visualization of film colors, see for instance Adelheid Heftberger (2018) and Christian Gosvig Olesen et al. (2016).

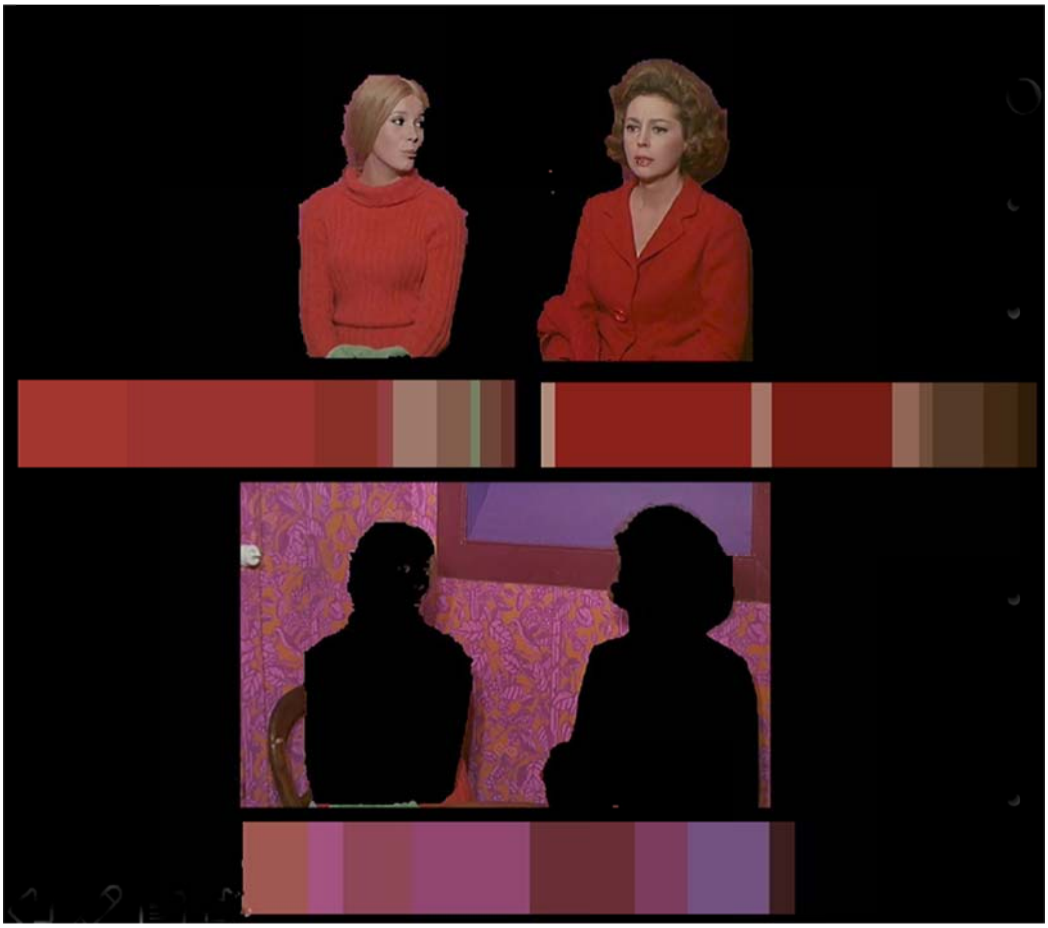

Figure 19 Figure–ground separation executed by Noyan Evirgen.

The methods implemented in VIAN go beyond these established methods both in the level of detail and in the scope of the visualizations. They perform a colorimetry to consider subtle developments of film color aesthetics on the level of single screenshots, temporal segments, and on corpus level connected to specific queries with one or more concepts defined in the controlled vocabulary.

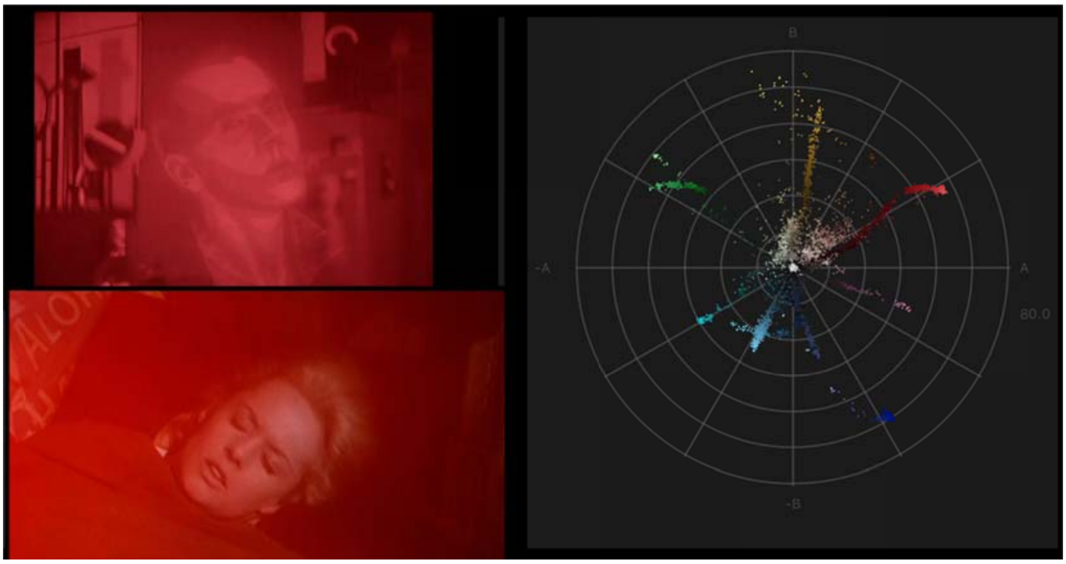

Figure 20 Visualization in VIAN for the query "dream sequences", 1895–1930, dot plot.

Visualizations are created in such a way that they render visual impressions in an immediate fashion and true to human visual perception in the perceptually uniform CIE LAB color system.

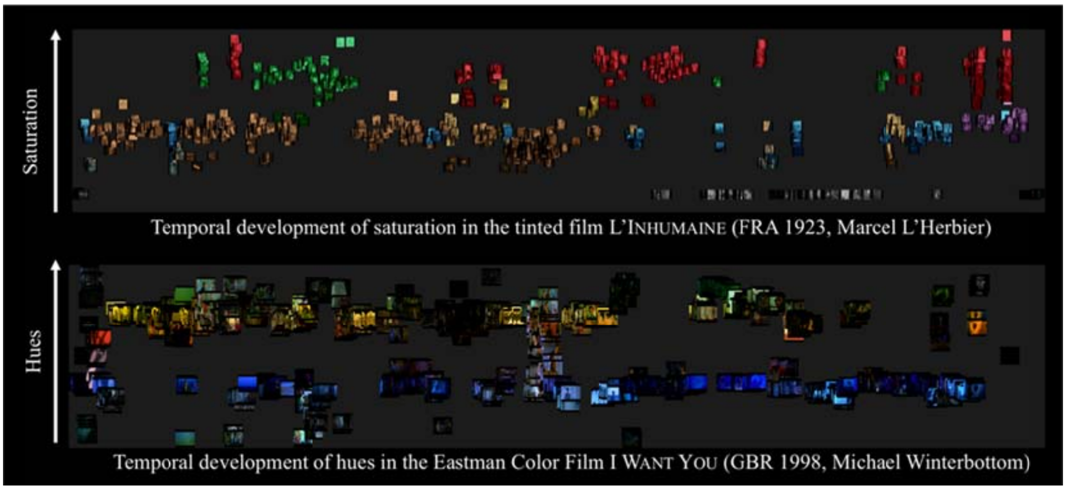

Figure 21 Temporal development of the color distribution in single films.

Temporal developments in films are plotted corresponding to saturation levels, chroma, hue or lightness. On the corpus level, similar plots display diachronic developments in selected periods, again for saturation, chroma, hue or lightness.

Most importantly, all the visualization methods include figure–ground separation as discussed in the previous section.

All of the methods are increasingly not only integrated in the VIAN software but are also becoming part of the VIAN WebApp. This interactive online portal is currently in development by Silas Weber and again Gaudenz Halter. It enables external users to work with the tools and to upload the results to the WebApp where they are processed by cloud computing to create the visualizations established in VIAN. In fall 2019 there will be an exhibition about film colors at the Fotomuseum Winterthur. An additional app is being programmed for this exhibition that connects the exhibits to the *Timeline of Historical Film Colors* and to visualizations created in VIAN. Thus an ever-growing *FilmColors* ecosystem is evolving.

All these methods of analysis and visualization are developed with film colors as a test bed. Further film-related research questions and plug-ins can be easily integrated into VIAN.

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